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Optimizing the microstructure of dissipative materials

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ABSTRACT

The aim of this work is to present a method to design material microstructures with high dissipation using topology optimization. In order to compute the macroscopic energy dissipation in periodic structures, we focus both on capturing the physical dissipation mechanism and to find the effective macroscopic dissipation.

The effective elastic material properties of a periodic structure can be found numerically using homogenization as describe in e.g. (Guedes and Kikuchi, 1990). For dissipative materials a quasi-static approach can be used to find the homogenized complex elasticity tensor, and thereby the material's loss factor, however, only for large wave lengths (small wave numbers) and constant material parameters (Andreasen et al., 2012). An alternative way to determine the material's loss factor is to consider the material's band diagram (Sigalas and Economou, 1992), from which the loss factor can be deduced.

Designs obtained by e.g. maximizing the material's loss factor for a given frequency range will be presented. The method will be demonstrated both using base cells consisting of continuum elements and base cells consisting of beam elements. The beam element base cell is included with inspiration from experimental results in (Schaedler, 2011), where a highly energy absorbing material, constructed from structural elements with a small cross sectional area but large area moment of inertia, is presented. Furthermore, the applicability of multiscale finite element methods (Efendiev, 2009) to account for boundary conditions of periodic structures that possess a finite extent is investigated.